REMARKS

Claim 28 has been amended to state that each further network element appears to each other further network element as an intermediate system within the routing area, and that the end systems are made known to the rest of the communications arrangement by Link State Protocol (LSP) packets generated by the one or more gateway network elements. The combination of features of amended claim 28 is not shown in any of the prior art documents or combinations thereof.

Basis for the amendments to claim 28 can be found on page 10, lines 8-10 and page 8, lines 13-14.

A key element of the present invention is that these further network elements, although being intermediate systems, are made to appear to other parts of the network as end systems. As set out in the description, by way of example, in a preferred embodiment the appearance of an end system is achieved by the gateway network element (GNE) preventing LSPs generated by the further network elements reaching the rest of the network and also by making the rest of the network believe that the GNE is at a domain boundary thus allowing the GNE to be manually set with end-system adjacencies on connections to the further network elements.

In this way the further network elements are made to appear to the rest of the network as end systems even though they are still intermediate systems and are still, for example, able to forward packets.

The present invention allows a significant improvement of communications systems by providing for reductions in the number of intermediate systems that any particular node has to deal with. This is achieved by masking the existence of large numbers of intermediate systems.

These advantages are not achieved by the system of Ambrosoli as it does not disclose the structure and function of amended claim 28.

Ambrosoli discloses a general configuration and the partitioning of a SDH network to achieve an effective structure that is resilient to link failure and that does not grossly increase overhead network traffic. Ambrosoli also addresses the issue of the co-existence between non-IS-IS and IS-IS network elements. However, there is no disclosure or suggestion of any reconfiguration of the gateway and further network elements to appear as end systems as required by amended claim 28. Further, each further network element does not appear to each other further network element as an Intermediate System within the routing area. Nor are the end systems made known to the rest of the communications system by Link State Protocol packets generated by the one or more gateway network elements. Thus, Ambrosoli fails to disclose or suggest many requirements of claim 28 and therefore applicant submits that claim 28 and its dependent claims are allowable.

Enclosed herewith is another copy of European Patent No. 0 895 380 which was submitted in the Information Disclosure Statement filed December 5, 2001.

Wherefore, a favorable action is earnestly solicited.

Respectfully submitted,

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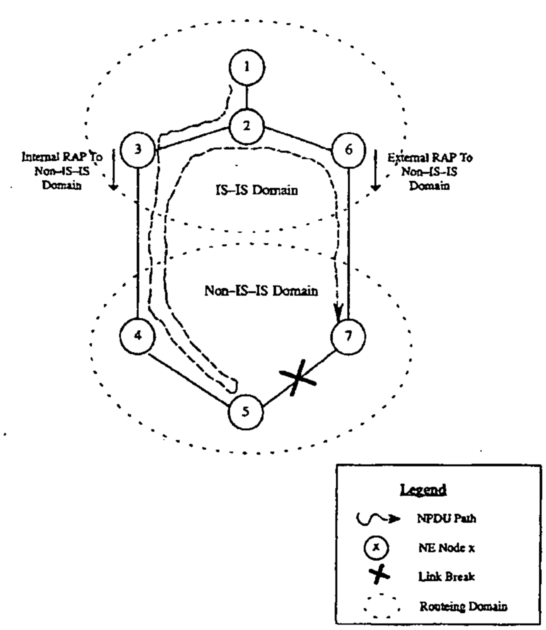
(54) Reachable Address Prefix alternative routing for iso 10589

(57) In a Synchronous Digital Hierarchy (SDH) based communications network comprising a plurality of Intermediate Systems (IS), the IS being divided between at least one IS-IS Area and at least one non-IS-IS Area, an IS-IS Area being an area with which a routeing protocol forming part of the Network Layer (Layer 3) of the Open Systems Interconnection including routeing (OSI), is provided for routeing messages between areas, including routeing means, whereby where a message is routed from an IS-IS Area to a destination IS within a non-IS-IS Area and the connection to the destination IS is broken, and as a result a message is returned from the non-IS-IS Area to the originating IS-IS Area connection to the destination IS is made by a second choice connection.

Figure 1.



EP 0 895 380 A2

Description

[0001] Synchronous Digital Hierarchy (SDH) equipment is the latest generation of equipment that is used to provide high bandwidth communications capabilities for use between telephone exchanges and in other areas where high quality telecomms is required (broadcast video distribution, etc). Embedded within the traffic 'traffic' carrying capability of the equipment are data communications channels (DCCs). These channels constitute a datacomms network that uses OSI protocols.

[0002] Each piece of equipment constitutes a routeing node in the datacomms network formed by the data channels, and can operate any one of a number of different routeing methods. The present invention is concerned with the interworking of two of the possible routeing method.

[0003] The two routeing methods that will commonly occur in SDH networks are IS-IS (ISO 10589) and quasi-static routeing (where alternate routes may be chosen on link failure). Where this occurs, routeing loops, causing loss of communications can be caused. The present invention detects the formation of a routeing loop and changes the behaviour of the IS-IS node accordingly.

[0004] The IS-IS routeing protocol is one of a set of 'link state' dynamic routeing protocols. These protocols automatically distribute routeing information round the datacomms network, allowing nodes to learn the required routeing information from the actual network. This provides the ability to automatically reconfigure, allowing routeing round network faults, in case of network link failure.

[0005] The IS-IS routeing protocol has two routeing levels, Level-1 and Level-2. See Figure 2 (from ISO 10589) for the use of these levels and the general environment of this protocol and the topologies and systems supported by Intradomain Routeing.

[0006] The present invention is also applicable to other datacomms scenarios, where a dynamic routeing protocol is interworked with static routeing, or a different dynamic protocol (e.g. OSPF and static routes, etc).

[0007] According to the present invention there is provided a Synchronous Digital Hierarchy (SDH) based communications network comprising a plurality of Intermediate Systems (IS), the ISs being divided between at least one IS-IS Area and at least one non-IS-IS Area, an IS-IS Area being an area with which a routeing protocol forming part of the Network Layer (Layer 3) of the Open Systems Interconnection including routeing (OIS), is provided for routeing messages between areas, including routeing means, whereby where a message is routed from an IS-IS Area to a destination IS within a non-IS-IS Area and the connection to the destination IS is broken, and as a result a message is returned from the non-IS-IS Area to the originating IS-IS Area connection to the destination IS is made by a second choice connection.

[0008] There is further provided a method for use in Synchronous Digital Hierarchy (SDH) based communications network comprising a plurality of Intermediate Systems (IS), the IS being divided between at least one IS-IS Area and at least one non-IS-IS Area, wherein when a message is returned from the non-IS-IS Area to the originating IS-IS Area a second choice connection to the destination IS is made.

[0009] The invention will now be described by way of example, with reference to the accompanying drawings, in which;

Figure 1 is a routeing diagram illustrating the invention; and

Figure 2 illustrates the ISO 10589 Level 1 and Level 2 IS-IS routeing protocols.

[0010] References:

[1] ISO/IEC 10589 : 1992 (E) Information technology - Telecommunications and information exchange between systems - Intermediate systems to Intermediate system intra-domain routeing information exchange for use in conjunction with the protocol for providing the connectionless-mode Network Service (ISO 8473).

[0011] Glossary:

Area - An IS-IS Level routeing subdomain
ES - End System - These systems deliver NPDUs to other systems and receive NPDUs from other systems, but do not relay NPDUs
External RAP Route A RAP Route derived from a RAP with metric type *External*
Internal RAP Route A RAP Route derived from a RAP with a metric type *Internal*
IS - Intermediate System (a node where data may be routed on to another IS or to an End System (ES))
IS-IS - The IS to IS intra-domain routeing protocol as specified in ISO 10589.
NE - Network Element
NPDU - Network Layer Protocol Data Unit
NSAP - Network Service Access Point
OSI - Open Systems Interconnection
RAP - Reachable Address Prefix
RAP Route Route derived from a RAP (regardless of whether the RAP is configured locally or on a remote *Router*)
Router An IS running IS-IS

[0012] *Level I Intermediate Systems* deliver and receive NPDUs from other systems, and relay NPDUs from other source systems to other designation systems. They route directly to systems within their own ar-

ea, and route towards a Level 2 Intermediate system when the destination system is in a different area.

[0013] *Level 2 Intermediate Systems* act as Level 1 Intermediate systems in addition to acting as a system in the subdomain consisting of Level 2 ISs. Systems in the Level 2 subdomain route towards a destination area, or another routeing domain. References to the routeing of NPDUs are made with regard to NPDUs destined for NSAPs residing on NEs in the non-IS-IS subdomain.

[0014] References to routeing over *RAP Routes* (whether *Internal* or *External)* pertain to routeing NPDUs, where the Address Prefix associated with the *RAP Route* is a prefix of the destination NSAP of the NPDU.

[0015] Knowledge of reference ISO 10589 is assumed and reference is made to terms defined in it. The *RAP Alternate Routeing* is an extension to IS-IS and resolves a problem when interworking with non-IS-IS. Although the present invention was born out of an IS-IS problem, it may have applications in other dynamic routeing protocols which use and discriminate between static route entries when interworking with other routeing protocols, whether dynamic, static or quasi-static.

[0016] IS-IS is a dynamic, link state based, routeing protocol which can be included as part of the Network Layer (layer 3) of the OSI Reference Model. For the purpose of this document, ISs running IS-IS will be termed *Routers.*

[0017] *Routers* can participate in two levels or routeing:

i) Level 1 - For routeing within an *Area*
ii) Level 2 - For routeing between *Areas*

[0018] Level 2 *Routers* provide the ability to enter static routes to NEs (and subdomains of NEs) which do not support IS-IS. These static routes are termed Reachable Address Prefixes (RAP) and they can have a metric type of either ***Internal*** or ***External.*** A level 2 *Router,* with a configured RAP, propagates the details of the RAP within it's Level 2 link state information. Thus all Level 2 *Routers* gain information about all RAPs configured with the Level 2 subdomain and calculate routes (*RAP Routes*) accordingly. When routeing decisions are made, *Internal RAP Routes* are selected in preference to *External RAP Routes.*

[0019] Since the NEs within the non-IS-IS subdomain do not propagate ISO 10589 link state information, the *Routers* cannot determine the state of routes beyond the boundary of the IS-IS subdomain. This means there is no way to monitor complete end-to-end routes which terminate in, or are routed through, the non-IS-IS subdomain.

[0020] There are two problems with this situation:

i) The inability to provide a second (back-up) route for resilience;
ii) The possibility of forming routeing loops when certain links in the non-IS-IS subdomain break (i.e. a *Router* may route NPDUs into the non-IS-IS subdomain and the non-IS-IS NEs may route the NPDUs back into the IS-IS subdomain).

[0021] *RAP Alternate Routeing* provides resilience when RAPs are used in a mixed routeing environment (i.e. to provide routes into non-IS-IS subdomains) by enabling automatic control of a second choice static route to non-IS-IS equipment. This makes uses of the two different metric types possible with RAPs ***(Internal*** and ***External)*** and will require one of each to be configured within the IS-IS subdomain.

[0022] The two problems i) and ii) above can be solved by selecting *External RAP Routes* when an NPDU is received on an *Internal RAP Route* and the originally selected outgoing route is an *Internal RAP Route.* By performing this function, *Internal RAP Routes* can be viewed as **primary** *RAP Routes and External RAP Routes* as **secondary** *RAP Routes.* Provision of this secondary route can provide resilience and can avoid routeing loops if the RAPs are configured correctly. A more detailed explanation is given below.

[0023] When a message (NPDU) is received on a circuit C associated with an *Internal RAP Route* and the selected outgoing route is an *Internal RAP Route,* the Routeing Table is searched for another *RAP Route* (i.e. a RAP Route other than the *Internal RAP Route* associated with circuit *C*). The two *Internal RAP Routes* can be different if the IS-IS parameter ***maximum Path Splits*** is set to 2. *External RAP Routes* are selected in preference to *Internal RAP Routes.* If no other *RAP Route* exists then the original *RAP Route* is selected (an NPDU forwarded on this route will probably loop and timeout in the network). The message is then forwarded on the circuit associated with the selected route.

[0024] This mechanism provides alternate routeing on a packed-by-packet basis. It does not change the state of the RAPs and hence does not advertise the fact that an alternate route has been used to the rest of the network. As soon as the non-IS-IS subdomain is repaired (i.e. it does not route NPDUs back into the IS-IS subdomain), the ***RAP Alternate Routeing*** will cease to be invoked, so the best available route will always be used.

[0025] As an example, referring to Figure 1, an NPDU from node 1 and destined for node 7 will be routed to node 2, on to node 3 and on to node 4 (since 3 has an *Internal RAP* to the non-IS-IS Routeing Domain).

[0026] It is necessary to make assumptions about the routeing in the non-IS-IS domain It is assumed that node 4 will route the NPDU to node 5 and that node 5 has no choice (because the link between nodes 5 and 7 is broken) and so routes the NPDU back to node 4. Also assume that node 4, now realising that a route to node 7 via node 5 does not exist, routes the NPDU back to node 3.

[0027] The actual mechanism of the routeing within the non-IS-IS domain is not significant, the key to invok-

ing the *RAP Alternate Routeing* is that an NPDU, destined for the non-IS-IS domain, returns to the IS-IS domain on a link, where a RAP to the non-IS-IS domain is configured.

[0028] The original IS-IS protocol will force node 3 to route the NPDU back into the non-IS-IS domain via node 4. At this point a probable routeing loop has occurred and the NPDU will expire (due to lifetime decay) within the network.

[0029] With *RAP Alternate Routeing* node 3 will detect that it is receiving a NPDU on a link which it should use to route the packet. It will detect that this link is an *Internal RAP Route* for the non-IS-IS domain and will invoke *RAP Alternate Routeing.* Node 3 will then route the NPDU to node 2 (i.e. on the *External RAP Route*).

[0030] Node 2 will receive the NPDU on an *Internal RAP Route* and will route the NPDU to 6 (i.e. on the *External RAP Route*).

[0031] Node 6 will receive the NPDU on an *Internal RAP Route* and will route the NPDU to 7 (i.e. on the *External RAP Route*).

[0032] Node 7 is the destination for the NPDU. Thus the routeing loop described above has been avoided and the NPDU has reached it's destination.

Claims

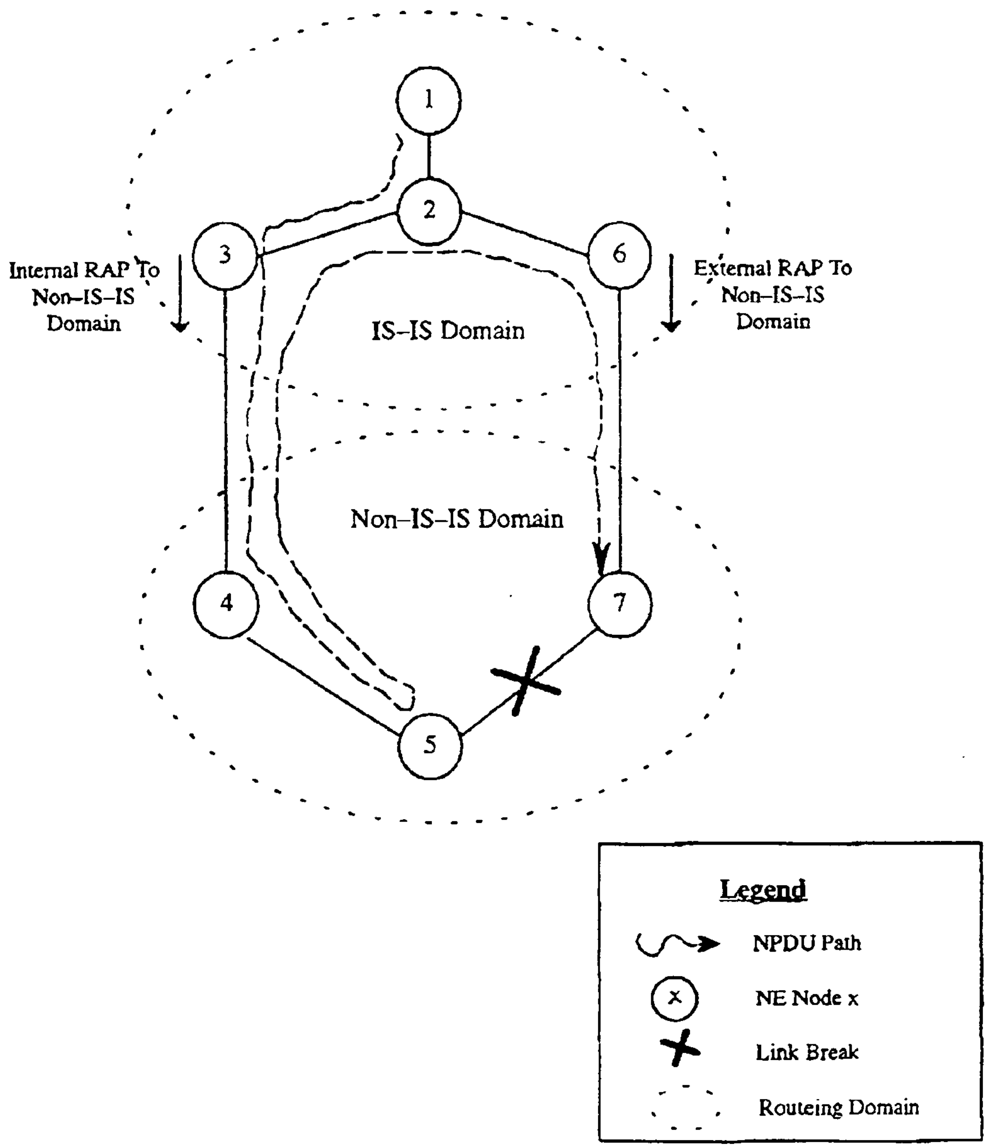
1. In a Synchronous Digital Hierarchy (SDH) based communications network comprising a plurality of Intermediate Systems (IS), the IS being divided between at least one IS-IS Area and at least one non-IS-IS Area, an IS-IS Area being an area with which a routeing protocol forming part of the Network Layer (Layer 3) of the Open Systems Interconnection including routeing (OSI), is provided for routeing messages between areas, including routeing means, whereby where a message is routed from an IS-IS Area to a destination IS within a non-IS-IS Area and the connection to the destination IS is broken, and as a result a message is returned from the non-IS-IS Area to the originating IS-IS Area connection to the destination IS is made by a second choice connection.

2. In an SDH network as claimed in Claim 1, the means being arranged so that where the message is received by the IS-IS Area from the non-IS Area by an Internal Reachable Address Prefix (RAP) Route having been sent to the non-IS-IS Area by an Internal RAP Route, the second choice connection is by an External RAP Route.

3. A method for use in a Synchronous Digital Hierarchy (SDH) based communications network comprising a plurality of Intermediate Systems (IS). the IS being divided between at least one IS-IS Area wherein when a message is returned from the non-IS-IS Area to the originating IS-IS Area a second choice connection to the destination to the destination IS is made.

4. A method as claimed in Claim 3. wherein where the message is received by the IS-IS Area from the non-IS-IS Area by an Internal RAP Route having been sent to the non-IS-IS Area by an Internal RAP Route, the second choice connection is by an External RAP Route.

Figure 1.


1
2
3
6
Internal RAP To Non-IS-IS Domain
External RAP To Non-IS-IS Domain
IS-IS Domain
Non-IS-IS Domain
4
7
5
Legend
NPDU Path
x
NE Node x
Link Break
Routeing Domain

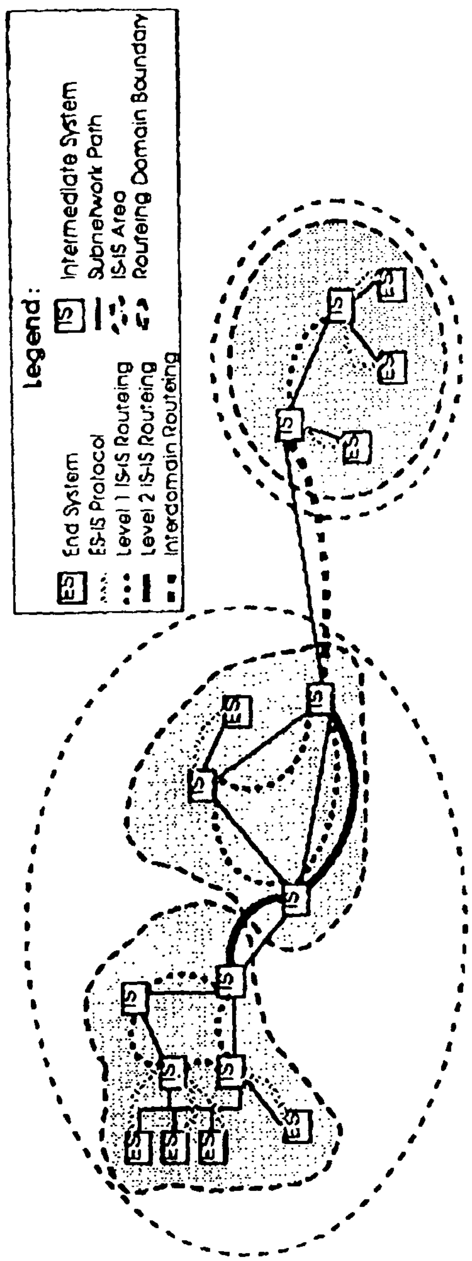

Legend:
ES End System
ES-IS Protocol
Level 1 IS-IS Routeing
Level 2 IS-IS Routeing
Interdomain Routeing
IS Intermediate System
Subnetwork Path
IS-IS Area
Routeing Domain Boundary
IS
ES

Figure 2